Site-Specific Variable Rate Fertilizer Nitrogen Application in Cotton

FREP Contract # 01-0507

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Introduction

The use of yields monitors, global positioning systems, remote sensing, and other attributes of site-specific crop management is increasing in California. California farmers who have adopted yield monitoring and mapping technology have frequently observed a high level of yield variability in their fields. In some cases growers have been able to interpret these yield maps based on their knowledge of the field and use this interpretation to improve their management and enhance profitability. However, the level of knowledge of this technology has not yet reached the state where growers can confidently adopt on a wide scale true site-specific management practices, that is, practices in which management is adjusted "on the go" to match the specific needs of each location in the field.

One of the most promising site-specific management practices is variable rate input application. In particular, variable rate application of fertilizers, especially fertilizer nitrogen, has been extensively studied in Midwestern cropping systems. Scientific investigations of the profitability of variable rate nitrogen application in the Midwest have produced equivocal results, with some investigations indicating a profit and others not. Much of the work in the upper Midwest has been motivated by regulatory concerns associated with potential contamination of ground and surface waters. Variable rate nitrogen application offers the potential for increasing profitability and reducing environmental effects of crop production if the increased costs associated with the practice can be offset by reduced input costs and/or reduced regulatory pressure.

The potential for variable rate fertilizer application to increase profit and resource use efficiency has not been investigated scientifically for California's diverse irrigated cropping rotations. Supported by FREP and other agencies, we have been investigating site-specific management of California field and row crops since 1995. This represents one of the longest and most extensive site-specific management research programs in California. Initial research focused on determining whether California fields have high yield variability, since they do not have the topographic variability often associated in the Midwest with high levels of yield variability. Our research and that of others has indicated that many laser leveled, surface irrigated fields in California display a high level of spatial variability in yield. Therefore the potential for improved economic and resource use efficiency of fertilizer exists, either by adding fertilizer to areas in which yield is limited by mineral nutrients or by reducing fertilizer rates in areas where yield potential is sufficiently reduced that high rates are unwarranted.

Also supported by FREP as well as other agencies, several of us have been carrying out research to more precisely quantify the nitrogen dynamics of modern California cotton varieties. Results of this research indicate that in some cases current nitrogen fertilization practices in California may not maximize fertilizer use efficiency. The application of nitrogen fertilizer at a site-specific rate may provide the opportunity for the grower to increase profits and maintain economic viability. At the same time, it provides the opportunity to demonstrate to the public and to regulatory agencies that the agricultural industry can use voluntary methods to reduce potential environmental contamination resulting from inputs to crop production systems.

The experiments carried out in this research project focus on using high spatial precision bulk data (yield maps, remotely sensed images, and soil EC_a values obtained from EM38 or Veris instruments) together with soil nitrate levels in the top two feet, obtained from soil cores taken through a directed sampling plan, to determine variable application rate in the first N application at layby. The experiments are carried out in commercial fields and the other aspects of crop management are the same as that of the rest of the field. In particular, any additional N applications based on petiole sampling and/or other information will be made at a uniform rate in the same manner as the rest of the field. Each experiment is carried out as a randomized complete block design with three levels: variable N rate, low fixed N rate control, and nominal fixed N rate. The low fixed N rate are calculated to maintain a total soil N level of 50 lbs./acre. This rate providsd an adequate control without forcing the cooperating grower to sustain an unacceptable economic loss. The nominal fixed rate treatment will be at the rate used by the grower in his own production The variable rate treatment is applied at a rate determined by an application rate map constructed according to soil productivity and estimated residual available N. Where salinity is high this dominates bulk EC measurements. In California fields where salinity is not a factor EC_a generally is a reflection of soil clay content (Rhoades and Corwin, 1990). In any case variations in EC_a often can be interpreted as indicating variations in soil properties within a field. We used data from bulk EC and yield maps from the previous year or years to develop a directed soil sampling plan.

Objectives

The overall objective is to determine whether variable rate nitrogen application is economically justified in California cotton production and if so, to determine a practical method for implementing it. Specific objectives are:

1. Develop a practical method for creating variable rate fertilizer nitrogen application maps based on existing yield maps, remotely sensed NDVI images, and /or soil bulk electrical conductivity maps and soil nitrate N levels obtained through directed pre-season sampling.

2. Conduct replicated experiments in large (typically quarter section) commercial fields in which the treatments are variable rate fertilizer application, fixed rate fertilizer application, and control.

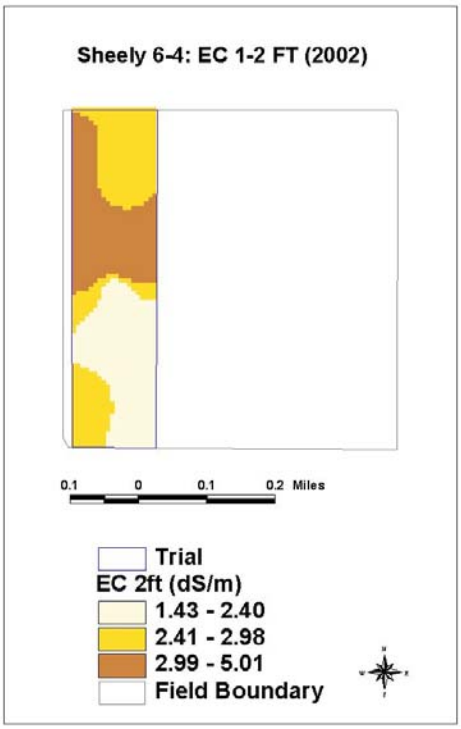
3. Conduct a partial budget economic analysis based on established methods to determine the economic viability of variable rate fertilizer application for California cotton production. Determine the breakeven acreage at which this method is profitable and the payoff period for purchase of equipment as well as the breakeven custom rate.

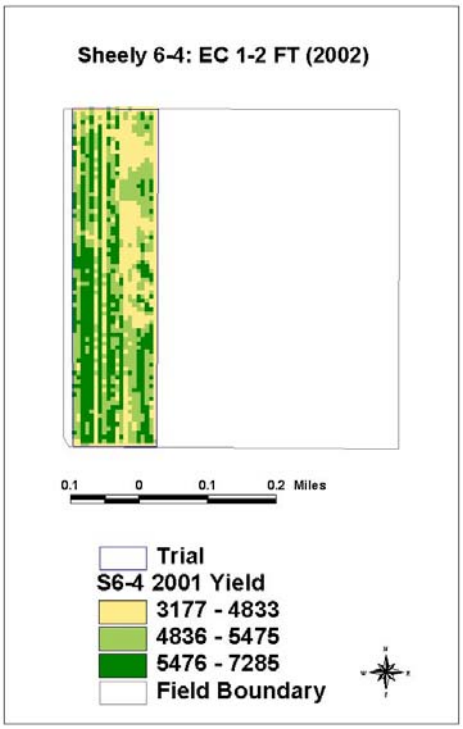
Results

We selected three fields on which to carry out the experiment. One is located at Sheely Farms in Lemoore, one is at M&M Farms near Hanford, and one is at Woolf Brothers

Farm in Lemoore. Fields were selected after testing soil at eight fields. Selection was based on availability of previous years' yield maps and on existence of a high level of variability in the field. In each of the fields we tested we took a total of 9 soil samples (three each in areas of high, medium, and low yield), and developed nitrogen application maps based on yield, soil nitrate N, and soil EC variability. We then selected the four fields having the most intrinsic variability in N rate. Soil testing was completed as specified. In each case we collected soil samples to measure nitrate N, as well as soil EC, collected with an EM38 inductance meter. Randomized complete block experiments were laid out as specified in each of the four experimental fields.

Figure 1 shows the soil bulk EC map, the previous year's yield map, and the resulting fertilizer rate map for one of the fields, the one located on Sheely Farms. Data are being collected during the course of the season including plant maps and petiole N levels. The final data set will be the yield maps for each trial. These data will be analyzed at the end of the season.





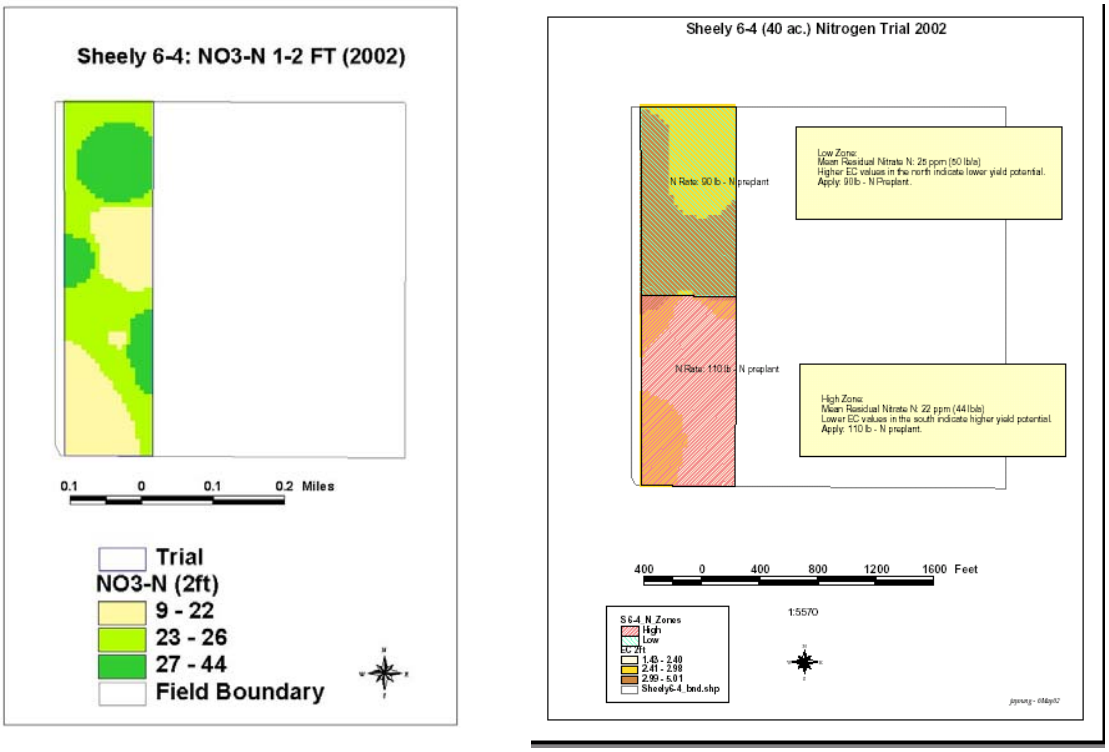


Figure 1. Bulk soil EC, 2001 yield, 2002 Nitrate – N levels, and resulting fertilizer application map.